Detection of glycosaminoglycan loss in articular cartilage by fluorescence lifetime imaging.

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Public Summary:
Glycosaminoglycan (GAG) loss is an early marker of osteoarthritis, which is a clinical late stage disease that affects millions of people worldwide. The goal of our study was to evaluate the ability of a fiber-based fluorescence lifetime imaging (FLIm) technique to detect GAG loss in articular cartilage. We used native bovine cartilage explants as a model system and systematically exposed these explants to increasing concentrations of an enzyme, chondroitinase ABC (cABC), to create samples with different levels of GAG loss. FLIm assessment was conducted on depth-resolved cross-sections of the cartilage sample. FLIm images, validated with histology, revealed that loss of GAG resulted in a decrease of fluorescence lifetime values compared to control samples. Fluorescence intensity ratio values were distinctly different from control samples as well. These results show that FLIm can detect the loss of GAG in articular cartilage and support further investigation into the feasibility of in vivo FLIm arthroscopy.

Scientific Abstract:
Glycosaminoglycan (GAG) loss is an early marker of osteoarthritis, which is a clinical late stage disease that affects millions of people worldwide. The goal of our study was to evaluate the ability of a fiber-based fluorescence lifetime imaging (FLIm) technique to detect GAG loss in articular cartilage. Native bovine cartilage explants (n = 20) were exposed to 0 (control), 0.5 (low), or 1 U / mL (high) concentrations of chondroitinase ABC (cABC) to create samples with different levels of GAG loss. FLIm assessment (excitation: 355 nm; detection: channel 1: 375 to 410 nm, channel 2: 450 to 485 nm, channel 3: 530 to 565 nm) was conducted on depth-resolved cross-sections of the cartilage sample. FLIm images, validated with histology, revealed that loss of GAG resulted in a decrease of fluorescence lifetime values in channel 2 (Delta = 0.44 ns, $p < 0.05$) and channel 3 (Delta = 0.75 ns, $p < 0.01$) compared to control samples (channel 2: 6.34 ns; channel 3: 5.22 ns). Fluorescence intensity ratio values were lower in channel 1 (37%, $p < 0.0001$) and channel 2 (31% decrease, $p < 0.0001$) and higher in channel 3 (23%, $p < 0.0001$) relative to control samples. These results show that FLIm can detect the loss of GAG in articular cartilage and support further investigation into the feasibility of in vivo FLIm arthroscopy.